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DECEMBER 1937

The Thermal Efficiency of the Rotary Cement Kiln.*

By HANS GYGI (ZURICH).

(Continued.)

(2) Actual Heat Balance for the Production of 1 kg. of Clinker.

Having calculated the heat effect for burning cement clinker, we proceed to draw up the actual heat balance for the rotary kiln.

The first step is accurately to measure the output and coal consumption of the kiln. The amount of clinker produced and the amount of coal consumed are best determined by weighing, as this is the safest way to obtain reliable values.

The quantity of air required for combustion and the volume of exit gas and its composition can be calculated from the chemical composition of the coal used by means of the analysis of the dry exit gas in conjunction with the output and coal consumption of the kiln.

The total heat input of the kiln can now be obtained by adding to the heat energy chemically combined in the coal the amount of heat transferred to the kiln by the slurry and the combustion air.

The heat consumption of the kiln consists of the heat effect of clinker burning as already calculated and the heat losses due to evaporating the water in the slurry, the considerable temperature at which the exit gases leave the kiln, radiation from the metal casing, and the heat still contained by the clinker when it leaves the cooler.

KILN OUTPUT AND COAL CONSUMPTION.—During the month in which the experiments were carried out the average output of the kiln was 8,500 kg. of clinker per hour, and the consumption of pulverised coal (calculated from the weighed quantities fed into the kiln and allowing for the mean water content) was 18.4 per cent. of the weight of clinker produced.

* The first part of this paper was given in our issue for November, 1937.

COAL.—The pulverised coal consisted of 2 parts Ruhress coal and 1 part of Saar coal. According to the test report of the Eidgenössische Materialprüfungsanstalt the analysis of the powdered coal was

Carbon	<i>c</i>	81.1	per cent.
Hydrogen	<i>h</i>	4.3	..
Oxygen	<i>o</i>	4.7	..
Nitrogen	<i>n</i>	1.2	..
Sulphur	<i>s</i>	1.0	..
Ash	<i>a</i>	7.2	..
Water	<i>w</i>	0.5	..

100.0 ..

The minimum calorific value of the coal was $H_u = 7,645$ Kcal. The volatile content determined by the American method was 24.7 per cent. of the water and ash-free sample.

RAW MATERIALS.—The mean water content of the thick slurry fed into the kiln during the experiment was 34 per cent. On the basis of the clinker analysis used for the calculation of the theoretical heat balance, the following raw materials were required for the production of 1 kg. of clinker:

1.221	kg.	CaCO_3
0.251	„	$\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$
0.099	„	SiO_2
0.810	„	H_2O

2.381 kg. slurry

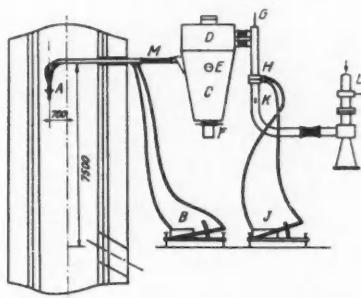
This quantity of raw material sufficed in practice to produce 1 kg. of clinker if we assume that the loss in the form of dust is balanced by the coal ash produced. The validity of this assumption is demonstrated by the dust determinations, which are also of interest from another point of view.

DUST LOSSES.—The dust content of the exit gas was determined by the Van Tongeren sampling apparatus⁸ used in conjunction with a "Bewag" cyclone⁹ as constructed by Rosenmüller of Dresden. In Fig. 2 are shown the arrangement of the apparatus, the instruments used, and the point in the stack, 7,500 mm. above the inlet from the fan, at which the samples were taken.

As it is most important when taking gas samples for the purpose of determining their dust content that the gas be delivered to the sampler at the same velocity as the main flow of gas, Van Tongeren furnished his apparatus with a device that ensures the constant agreement of the two gas velocities throughout the experiment. This is done simply by maintaining equilibrium between the static pressures at two different parts of the apparatus. The dust-laden gases enter the electrically heated cyclone in which the coarse dust is separated out. The fine dust is retained on four cellulose filters placed above the cyclone. These filters must be weighed in the dry condition before the experiment begins. At the conclusion of the experiment the coarse dust is dried and weighed, and the filters charged with the fine dust are also dried and weighed. The result gives the dust

⁸ Van Tongeren, "De Ingenieur," No. 16 (1930).

⁹ E. Zimmermann, Z. V. D. I., No. 16 (1931).



A.—Van Tongeren sampler. B.—Rosenmüller micro-manometer. Inclination of manometer tube $n = 1:25$. C.—Bewag-cyclone. D.—Filter box with 4 dried and weighed cellulose filters for the fine dust. E.—Connection for heater for C. F.—Receptacle for coarse dust. G.—Thermometer for temperature control of measuring tube. H.—Measuring tube. J.—Rosenmüller micro-manometer. Inclination of manometer tube $n = 1:5$. K.—Connection for heater for H. L.—Adjustable compressed air supply for gas pump. M.—Length of tube insulated to prevent condensation.

Fig. 2.—Diagram showing arrangement of apparatus using the van Tongeren dust sampler and the Bewag-cyclone.

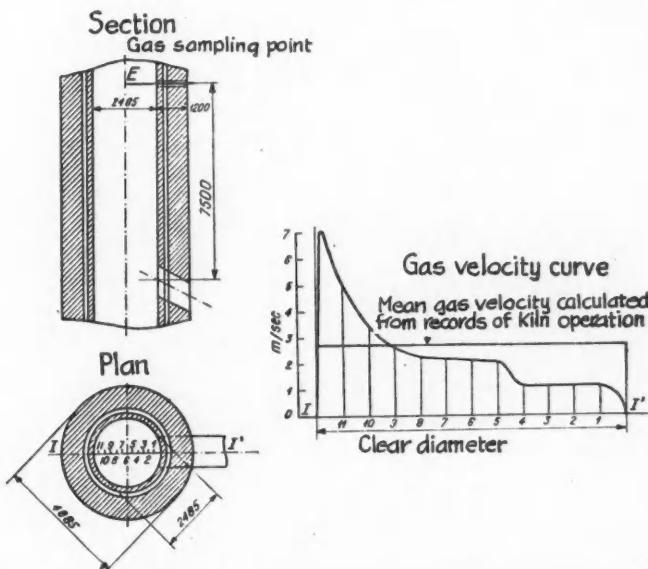


Fig. 3.—Position of sampling point for dust determination and curve for velocity of gas in the stack.

content of the sample taken from the main stream of gas. The cleaned gas now passes into the measuring tube, which is also electrically heated, and the amount of gas passing per unit of time is measured by an orifice-type flow meter. The gas is drawn through the apparatus by a compressed air pump.

In order that the sampling apparatus should operate at the point in the cross-section of the stack where approximately the mean gas velocity obtained, it was first necessary to determine the gas velocity distribution across the stack by means of Prandtl's flow meter. The curve obtained is shown in *Fig. 3*.

The results of a three-hour experiment are given in Table 2. The amount of dry dust collected in this test was 23.75 g. Of this, 7.35 g. were dry coarse dust from the cyclone and 16.4 g. fine dust retained on the cellulose filters.

During the experiment 7.415 Nm³* dry gas were taken from the main stream of gas by means of the sampling apparatus. The dust content of the dry gas was therefore

$$\frac{23.750}{7.415} = 3.20 \text{ g. dust per Nm}^3 \text{ dry gas.}$$

With the amount of excess air shown by the analysis for the cross-section at which the sample was taken, the dry gas amounts to 2.12 Nm³ per kg. of clinker and therefore the amount of dust produced per kg. of clinker is $2.12 \times 3.20 = 6.784$.

Chemical analysis of the dust samples showed that one-third of the coarse dust and four-fifths of the fine dust consisted of alkali sulphates readily soluble in water.

TABLE 2.—DUST CONTENT OF THE EXIT GAS.

Time (hours and minutes)	Temperature at sampling point (deg. C.)	Atmospheric pressure— negative pressure (mm. Hg.)	Sampling point A	P (mm. H ₂ O)	V (m ³ /h.)	V (Nm ³ dry./h.)
10.45	49		1.003	7.55	5.08	2.60
10.48	63		0.962	8.38	5.45	3.00
10.51	69		0.945	8.88	5.08	2.73
10.54	71		0.939	8.88	5.70	2.73
10.57	72		0.937	7.55	5.26	2.08
11.00	79		0.918	9.33	5.90	2.75
11.15	83		0.908	8.88	5.78	2.68
11.30	86		0.900	8.00	5.52	2.52
11.45	87	731.2 — 3.2	0.898	7.11	5.22	2.39
12.00	85	= 728 mm. Hg.-column	0.902	6.66	5.03	2.30
12.15	87		0.898	8.44	5.68	2.60
12.30	84		0.906	8.00	5.50	2.53
12.45	85		0.902	8.88	5.81	2.67
13.00	86		0.900	6.66	5.03	2.30
13.15	85		0.902	8.00	5.52	2.53
13.30	85		0.902	5.77	4.68	2.15
13.33	85		0.902	5.77	4.68	2.15
13.36	85		0.902	6.22	4.87	2.23
13.39	84		0.906	5.33	4.48	2.07
13.42	84		0.906	5.77	4.67	2.15
13.45	84		0.906	5.33	4.48	2.07
Mean values	83.24	728	0.90747	7.62	5.35	2.47

* Nm³ = Standard cubic meter (1 atm. pressure and 0 deg. C.).

During the three hours the experiment lasted, the dust that settled in the smoke box was weighed and found to amount to 36 kg. per hour. At this rate the dust loss amounted to 93.7 kg. for an ash production of 113 kg. per hour, so that no error will be introduced into the heat balance if it is assumed that the dust losses are balanced by the ash production.

Gas Quantities.

(a) AIR REQUIREMENTS.—The theoretical amount of air required by the kiln per kg. of clinker is found from the ultimate analysis of the pulverised coal by means of the formula

$$Q_{th} = 0.184 \left[8.88c + 26.7 \frac{(h - o)}{8} + 3.3s \right] \text{Nm}^3/\text{kg.} \quad \dots \quad (1)$$

$$Q_{th} = 1.51 \text{ Nm}^3/\text{kg. clinker.}$$

In order to be able to calculate the actual, or effective, air requirement from the theoretical air requirement we must know the coal consumption and the chemical composition of the exit gas. The results of a test which lasted several hours are given in Table 3, and in Fig. 4 are shown the position at which the gas was sampled and the variation of the CO_2 , CO , and O_2 contents with time.

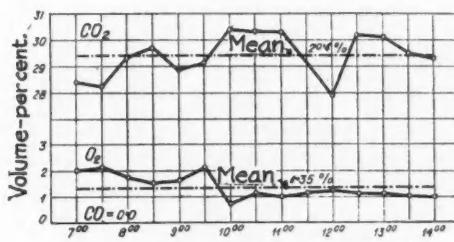
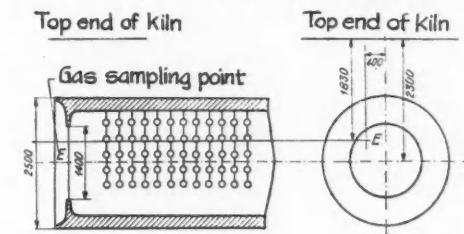


Fig. 4.—Analysis of gas leaving kiln.

According to the gas analysis there was on an average 8 per cent. of air in excess of the quantity required for combustion, so that the effective air requirement was

$$Q_{eff} = 1.51 \times 1.08 = 1.63 \text{ Nm}^3/\text{kg. clinker.}$$

Of the air required for combustion 18.1 per cent. passed directly into the kiln with the pulverised coal as primary air, while the remaining 81.9 per cent. was introduced into the kiln as pre-heated secondary air.

TABLE 3.—EXIT GAS ANALYSES.

Time of sampling (hours and minutes)	Value (%)			Quantity per hour in cm. height in vessel (cm/h)	Coal consumption Tachometer (r.p.m.)
	CO ₂	O ₂	CO		
7.00	28.4	2.0	0.0	26	43
7.30	28.2	2.1	0.0	27	43
8.00	29.3	1.7	0.0	24	50
8.30	29.7	1.5	0.0	27	46
9.00	28.9	1.6	0.0	26	44
9.30	29.1	2.1	0.0	26	50
10.00	30.4	0.7	0.0	26	45
10.30	30.3	1.1	0.0	26	45
11.00	30.3	1.0	0.0	26	44
11.30	29.3	1.1	0.0	27	42
12.00	27.9	1.2	0.0	26	42
12.30	30.2	1.1	0.0	27	45
13.00	30.1	1.1	0.0	26	45
13.30	29.5	1.0	0.0	27	44
14.00	29.3	1.0	0.0	27	44
Mean values ..	29.4	1.35	0.0	26.2	44.8

(b) COMBUSTION GASES.—The quantities of gas per kg. of clinker are obtained from the fuel consumption, the ultimate analysis of the pulverised coal, and the air requirement.

		Nm ³
0.184 × c kg. C	produce 0.184 × 1.86 × 0.811 = 0.277	CO ₂
0.184 × h kg. H ₂	0.184 × 11.2 × 0.043 = 0.089	H ₂ O
0.184 × s kg. S	0.184 × 0.70 × 0.010 = 0.001	SO ₂
0.184 × n kg. N ₂	0.184 × 0.80 × 0.012 = 0.002	N ₂
0.184 × w kg. H ₂ O	0.184 × 1.24 × 0.005 = 0.001	H ₂ O
N ₂ of the theoretical air requirement	1.51 × 0.79 = 1.190	N ₂
Excess air	= 0.120	Air

Combustion gases 1.680 Nm³

(c) WATER VAPOUR AND CARBON DIOXIDE FROM RAW MATERIAL.—The quantities of water vapour and carbon dioxide per kg. of clinker which are evolved from the raw materials are obtained from the chemical composition of the raw slurry.

Nm ³		
H ₂ O from slurry	0.810 $\frac{22.4}{18}$	= 1.008 H ₂ O
H ₂ O from kaolin	0.035 $\frac{22.4}{18}$	= 0.043 H ₂ O
CO ₂ from calcium carbonate	0.537 $\frac{22.4}{44}$	= 0.273 CO ₂

Water vapour and carbon dioxide from raw material = 1.324 Nm³

Temperature of Exit Gas.

The temperature of the exit gas was measured at the exit cross-section of the kiln by means of the pyrometer described and illustrated in the next section.

The results are given in Table 4 and are shown graphically, together with the gas temperatures measured inside the kiln, in *Fig. 11**. As the heat balance has to be based upon the corrected mean value for the true exit gas temperature, the gas velocity distribution at the exit cross-section was taken into account in the determination of this mean value. Calculated in this manner the true exit gas temperature at the exit cross-section was 226 deg. C. The same value for the exit gas temperature is obtained by taking the arithmetical mean of the

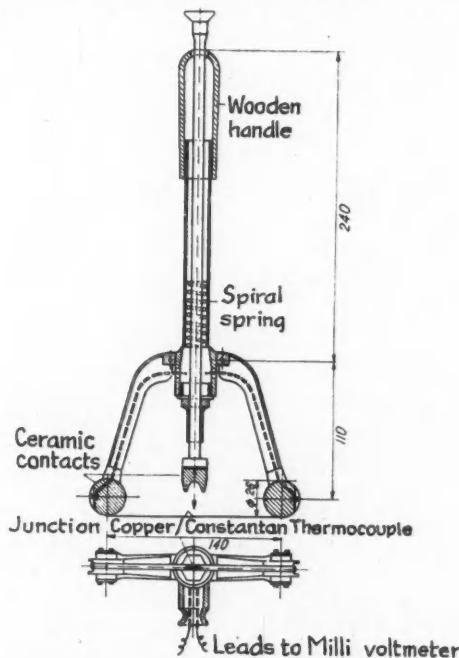
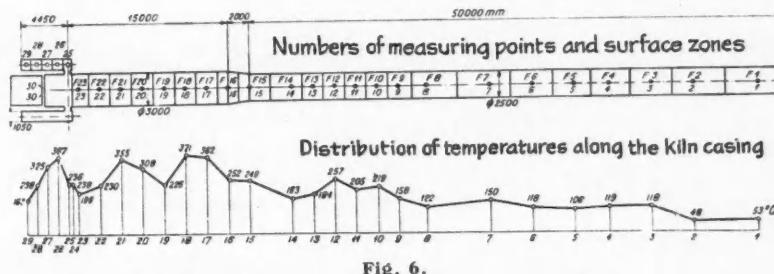


Fig. 5.—Pyrometer used for measuring the surface temperature of the Kiln casing.



* Fig. 11 will be included in the next part of this paper.

TABLE 4.—TEMPERATURES AT EXIT CROSS-SECTION.

Measuring point	t_1 hot junction (deg. C.)	t_2 cold junction (deg. C.)	t_2 corrected (deg. C.)	t (deg. C.)	Measuring point	t_1 hot junction (deg. C.)	t_2 cold junction (deg. C.)	t_2 corrected (deg. C.)	t (deg. C.)	Mean value of true gas temperatures (deg. C.)
1	158	20.0	19.6	177.6	1	150	24.0	23.5	173.5	175.5
2	174	20.0	19.6	193.6	2	162	24.0	23.5	185.5	189.5
3	187	20.0	19.6	206.6	3	177	24.0	23.5	200.5	203.5
4	201	21.0	20.6	221.6	4	190	24.0	23.5	213.5	217.5
5	216	21.0	20.6	236.6	5	193	23.0	22.5	215.5	226.0
6	220	21.0	20.6	240.6	6	210	23.0	22.5	232.5	236.5
7	233	21.0	20.6	253.6	7	220	23.0	22.5	242.5	248.0
8	238	21.0	20.6	258.6	8	230	23.0	22.5	252.5	255.5
9	236	21.0	20.6	256.6	9	230	23.0	22.5	258.5	257.5
10	224	21.0	20.6	244.6	10	235	22.0	21.6	256.6	250.5
11	222	21.0	20.6	242.6	11	230	22.0	21.6	251.6	247.0
12	216	21.5	21.0	237.0	12	228	22.0	21.6	249.6	243.5
13	209	21.5	21.0	230.0	13	219	22.0	21.6	240.6	235.5
14	192	21.5	21.0	213.0	14	201	22.0	21.6	222.6	218.0
15	168	21.5	21.0	189.0	15	170	21.5	21.0	191.0	190.0

TABLE 5.—CALCULATION OF THE HEAT LOSSES FROM THE KILN CASING BY RADIATION AND CONVECTION.

Measuring point	Surface area (m ²)	t of surface (deg. C.)	Surface temperature minus air temperature (deg. C.)	Heat transfer coefficient (Kcal./m ² /h/°C.)	Heat loss from each zone (Kcal./h.)
1	39.30	53	18	9.1	6,437
2	39.30	48	13	9.0	4,598
3	31.40	118	83	11.5	29,971
4	29.10	119	84	11.0	28,355
5	29.10	106	71	11.0	22,727
6	31.40	118	83	11.5	29,971
7	39.30	150	115	13.0	58,753
8	33.80	122	87	11.7	34,405
9	18.10	158	123	13.4	29,832
10	15.70	219	184	16.7	48,243
11	15.70	205	170	16.0	42,704
12	15.70	257	222	19.3	67,268
13	15.70	184	149	14.7	34,388
14	23.00	163	128	13.6	41,083
15	23.90	249	214	18.8	96,154
16	18.40	252	217	19.0	75,863
17	18.85	302	327	27.2	107,659
18	18.85	371	336	27.9	176,707
19	18.85	226	191	17.2	61,926
20	18.85	308	273	22.9	117,844
21	18.85	355	320	26.6	160,451
22	18.85	230	195	17.5	64,326
23	10.61	196	161	15.5	26,477
24	7.80	238	203	18.0	28,501
25	15.96	236	201	17.9	57,422
26	17.75	367	332	27.6	162,647
27	17.75	325	290	24.2	124,560
28	17.75	238	203	18.0	64,858
29	15.96	163	128	13.6	27,783
30	2.03	212	177	16.3	5,867
Total ..	638.21				1,897,789

TABLE 6.—HEAT BALANCE.

Credits.	Fuel consumption per kg. clinker (kg.)	Lower calorific value of fuel (Kcal./kg.)	Calories per kg. of clinker (Kcal./kg.)
Supplied by the fuel . . .	0.184	7,645	1,407
	Quantity per kg. of clinker	Specific heat (Kcal./kg./deg. C.)	Temperature (deg. C.)
Primary air . . .	0.295 Nm ³	0.313	38
Secondary air . . .	1.335 Nm ³	0.313	25
Raw slurry . . .	2,454 kg.	0.496	25
Total . . .			1,451
Debits	Quantity per kg. of clinker	Specific heat (Kcal./kg./deg. C.)	Calories per kg. of clinker (Kcal./kg.)
Theoretical requirement for burning clinker $\text{CO}_2 + \text{SO}_2$			448
Combustion gases . . .	0.278 Nm ³	0.430	27
N_2 of theoretical air requirement . . .	1.190 Nm ³	0.316	226
Excess air . . .	0.120 Nm ³	0.316	226
H_2O combustion gases	0.089 Nm ³	0.375	226
CO_2 raw material . . .	0.273 Nm ³	0.430	226
H_2O slurry :—			
(a) evaporation . . .	1.009 Nm ³		482
(b) heating . . .	1.009 Nm ³	0.375	226
H_2O kaolin . . .	0.043 Nm ³	0.375	226
Clinker . . .	1,000 kg.	0.193	175
Radiation losses			34
Unconsumed not determined . . .			223
Total . . .			18
			1,451

temperatures recorded in Table 4. This is probably due to the fact that the gas velocity at the exit cross-section decreases approximately in proportion to the square of the distance from the axis of the kiln, whereas the areas increase with the square of the distance.

Heat Losses from the Kiln Casing by Radiation and Convection.

The surface temperatures of the steel casing were measured with the copper-constantan surface pyrometer, constructed by Siemens and Halske, illustrated in *Fig. 5*.

The 30 points at which the measurements were made are shown in *Fig. 6*, which also gives the temperature distribution along the outside of the kiln and the cooling tube. The peak at point 21 clearly indicates the cross-section at which the clinker is sintered. On the other hand, the relatively low temperatures recorded at points 19 and 22 show that a thick crust has formed on the refractory lining at these cross-sections. The calculation of the heat losses was based on a mean air temperature within the kiln house of 35 deg. C. and Heilmann's¹⁰

¹⁰ R. H. Heilmann, "Ind. and Eng. Chemistry," page 451 (1924).

values for the heat transfer coefficients were used. The heat loss calculations for the various zones are given in Table 5.

The total heat loss from the kiln casing by radiation and convection was 1,897,000 Kcal. per hour, which corresponds to 223 Kcal. per kg. clinker for a kiln output of 8,500 kg. per hour.

Heat Balance.

In the light of the foregoing discussion of kiln output, coal consumption, volume and temperature of exit gas, and radiation losses from the kiln casing, and having regard to the heat effect calculated in Section 1, we can now draw up for the kiln under investigation the complete heat balance for burning 1 kg. of clinker (Table 6).

The heat balance is based upon the temperature 0 deg. C., and the lower calorific value of the coal is taken. On the credit side, therefore, we must include, besides the heat supplied by the coal, the heat introduced into the kiln with the combustion air and the raw slurry.

The debits consist of the heat usefully expended and the heat lost. The items are shown separately in Table 6. The undetermined losses shown in Table 6 as 18 Kcal. per hour must be due to unconsumed fuel. This proportion seems rather low, but when output and coal consumption were measured the kiln was running quite smoothly.

(To be continued.)

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MISCELLANEOUS SHAFT KILNS (*continued*).

Rotary Kilns.

Rotary Kilns for Burning Limestone.—Rotary kilns have already been discussed briefly⁵ and their fundamental limitations have been mentioned. Nevertheless, under some conditions their advantages are such that their use is steadily growing in the United States where a considerable proportion of the total lime is made in them. They have the advantages of very low labour cost, and, if properly operated, of producing lime of good and uniform quality, and their higher fuel and power requirements are of less importance in the United States than in Europe. Moreover, their efficiency is gradually being improved, mainly by increasing the length of the kilns, which also increases their first cost. Recent plants closely follow the design of modern cement kilns, including the use of coolers forming part of the kiln structure.

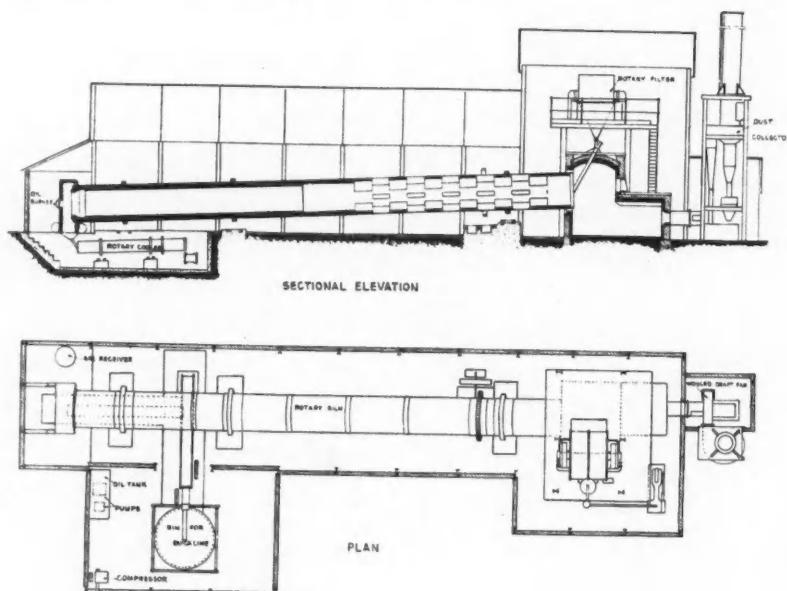
As an indication of the size and output of a modern plant the following particulars of one recently put into operation in the United States are of interest⁶. The kiln is 290 ft. long, a length of 187 ft. from the feed end being 5 ft. 6 in. internal diameter and a length of 93 ft. at the discharge end having an internal diameter of 6 ft. 9 in., with a 10 ft. taper section between the two. Near the feed end a section 56 ft. long is divided by radial partitions into quadrants which increase the heat transfer and are said to be equivalent to an extra 45 ft. of length. The lining is 7½ in. thick without insulation in the high-temperature zone and 4 in. thick with 2½ in. of insulation through the zone of lower temperature. The capacity of this kiln is said to be 125 to 150 tons per 24 hours, with a temperature in the burning zone of 1,260 deg. C. to 1,320 deg. C. It is fired with coal dust. The lime is cooled in a Unax cooler consisting of ten cylinders 30 in. in diameter and 10 ft. long equipped with chains to facilitate heat transfer. The lime is said to be in the kiln between five and six hours and in the cooler one hour.

Rotary kilns for the production of lime of the highest quality are gas or oil fired, but coal-dust firing is frequently employed and the degree of contamination is seldom sufficient to be an important consideration. Of more importance is the skin of contaminated lime which forms on the outside of the lumps if the burning temperature is too high. By control of temperature and of the rate of passage through the kiln this may be reduced to a minimum, and coal-dust-fired lime is coming more and more into use.

*Previous articles in this series appeared in our issues for January, February, March, April, May, August, September, October and November this year.

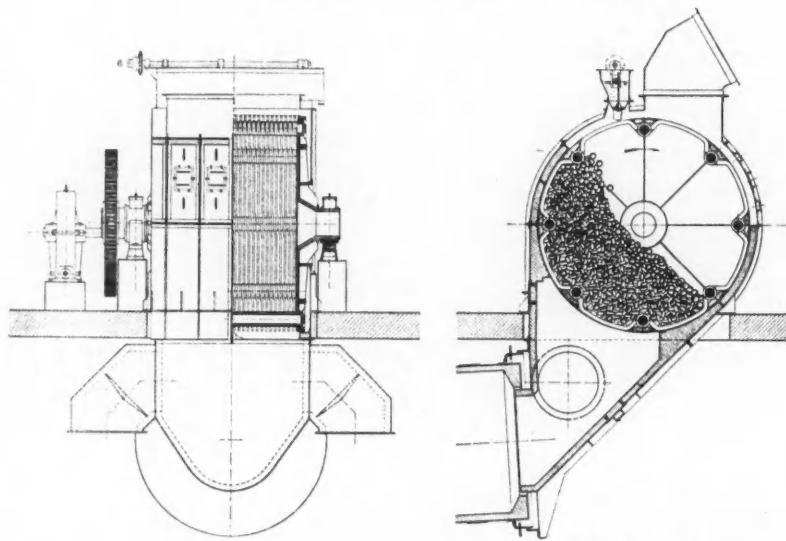
⁵ *Cement and Lime Manufacture*, Feb., 1937, p. 56.

⁶ *Rock Products*, Aug., 1937, p. 45, and *Pit and Quarry*, Aug., 1937, p. 41.



(Edgar Allen & Co., Ltd.)

Fig. 44.—Rotary Kiln and Auxiliaries for CaCO_3 sludge.



(Krupp-Grusonwerk.)

Fig. 45.—Sludge "Concentrator."

A natural gas-fired rotary kiln is used in Texas for calcining oyster shells to lime, and rotary kilns have also been used for chalk for which they would appear to be well suited, but at present chalk lime is not being produced in them.

Rotary Kilns for Sludge.—In many chemical processes calcium carbonate is precipitated and is eliminated from the process as a sludge. This occurs in causticising, in which process enormous quantities of calcium carbonate sludge are produced, in paper factories, etc., and in the softening of some kinds of water. To reconvert this sludge into lime the rotary kiln has proved to be the only practicable plant, and it is used for calcining large quantities of these sludges. The plant used is practically the same as for dry stone, but the feed end should be adapted to deal with the sludge and in this respect it is the same as a wet-process cement kiln. Calcium carbonate sludges generally carry much more water than cement slurry, and it is generally necessary to reduce this by filtering before feeding the sludge to the kiln. The usual arrangement is a rotary vacuum filter on to which the sludge is run and from which the cake falls directly into the kiln. An arrangement of this kind is shown in Fig. 44, and it will also be seen that the preheating end of the kiln is fitted with lifter plates to cascade the material and thus increase heat transfer.

Alternatively, an apparatus similar to that used in cement burning, and generally called a concentrator, may be used where a fairly thick sludge is available. A concentrator of this type is shown in Fig. 45. It consists of a rotating drum made up of two end walls and a series of elements which form in effect a cylindrical grid or screen. The drum is nearly half filled with metallic rings. The slurry is fed through the grate on to the rings which it coats, and the hot gases pass up through the drum, their intimate contact with the slurry coating the rings resulting in a high rate of heat exchange and the rapid evaporation of the moisture. When it is dry the slurry breaks off the rings and falls through into the kiln.

Calcium carbonate sludges from causticising generally contain a considerable amount of alkali which it is impossible to wash out completely. The effect of this alkali is to decrease the temperature at which overburning of the lime takes place and to increase the rate of destruction of the kiln lining. Sludge kilns must, therefore, be operated at lower temperatures than those burning limestone. The alkali, or other impurities, however, helps the fritting together of the lime to form nodules or lumps, which feed forward and turn over in the kiln like cement clinker. A pure calcium carbonate sludge is difficult to burn because it remains a dusty powder which upsets the normal operation of the kiln.

OTHER METHODS OF LIME BURNING.

Retorts.—In all the kilns hitherto discussed the carbon dioxide evolved from the stone is mixed with products of combustion of the fuel. If it could be kept separate it would have considerable value in industrial districts, but the only practicable way of accomplishing this is by the indirect heating of the stone in ovens or retorts. There is no difficulty in calcining lime in fireclay retorts be-

cause the temperature required is well below that commonly employed in high-temperature coking practice, but the difficulties of economic production are considerable. They are due not only to the relatively high cost of the equipment, but to the large amount of heat which has to be transmitted through the retort and through the calcined lime within the retort to bring about calcination. The low conductivity of burnt lime enhances the difficulty. The heat absorbed in calcination is very greatly in excess of that required for the coking of coal and in similar retort operations, and most of the heat is used up at a high temperature, 900 deg. C., whereas in coking most of the heat is used at the lower temperatures.

Retorts built of carborundum have been proposed and used for making pure lime and pure carbon dioxide from limestone by the Gillette process, which employs a continuous oil-fired vertical retort 24 ft. high and 20 in. by 3 in. in cross-section. The high temperature which this material will withstand permits the use of extremely high external temperatures which overcome to some extent the disabilities mentioned, but it is doubtful whether such retorts are economically successful. Retorts are being used for the calcination of magnesite, which requires a much lower temperature.

Limestone mixed with coal has been calcined and coked in coke ovens to produce the mixture used in carbide manufacture, but the process is not in commercial use.

Electrical Calcination.—The electrical calcination of lime has been proposed in countries where coal is exceptionally expensive and water power is cheap. The methods proposed have varied from rotary retorts heated by resistance windings to vertical shafts heated by a current of gases from an arc furnace. These gases may be carbon dioxide which is circulated in closed circuit, the excess being removed continuously. It is doubtful whether electrical calcination will ever be of more than minor and local importance. Most of the suggestions for its use have been based upon a misconception as to the amount of heat, and, therefore, of electricity required in the process. At 100 per cent. efficiency a kilowatt-hour will produce $2\frac{1}{2}$ lb. lime, so that 900 kwh. are required to produce a ton of lime.

(To be continued.)

The Separation of Magnesia from Dolomite.

By DR. C. R. PLATZMANN.

DOLomite is a mineral which contains a double carbonate of calcium and magnesium in molecular proportions, but efforts to separate dolomite into magnesia and calcium oxide have not yet reached a commercial stage. The following notes on some experiments made by the author are given as a contribution to the solution of the problem.

In the process the mineral itself, burnt dolomite ground to an impalpable powder or crushed to pea-size, was used. Treatment with a solution of bicarbonate of alkali followed. The burnt or unburnt dolomite was suspended in this solution, which was also saturated with carbon dioxide. At a temperature of 140 to 154 deg. F. the magnesia dissolved to a double salt of alkali and magnesia, while the lime was precipitated as calcium carbonate. The filtered solution changed at 212 deg. F. into insoluble carbonate of magnesium, the carbonate of alkali, however, remaining in solution.

The dolomites used had the following composition :

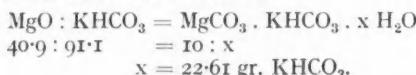
No.	SiO ₂ .	R ₂ O ₃ .	CaO.	MgO.	Ignition loss.
1	Per cent. 1.02	Per cent. 0.96	Per cent. 32.82	Per cent. 18.96	Per cent. 45.80
2	0.84	1.88	31.67	20.51	45.00

In all the experiments described burnt dolomite was used. It seemed advisable for this reason to define first the most favourable temperature of burning, i.e. the temperature which gave the quickest and most complete dissociation of carbon dioxide from the dolomite.

One portion of the raw dolomite was crushed to pea-size, while another portion was ground to an impalpable powder. The burning process took place at temperatures between 1,540 and 2,120 deg. F., the duration of burning being changed according to the requirements. There was no difference between the coarse and fine material in so far as temperatures from 1,840 until 2,120 deg. F. were applied. After burning for 8 to 9 hours at a temperature of 1,840 deg. F. the whole of the carbon dioxide was driven out, while with a temperature of 2,120 deg. F. 99 per cent. of the carbon dioxide escaped within one hour. These preliminary experiments showed that with a temperature of 1,540 deg. F. the pea-size dolomite dissociated more easily than the finely ground material. The dissociation of the dolomite into carbon dioxide and calcium oxide and magnesia started at a temperature of 1,202 deg. F.; 95 per cent. of the carbon dioxide had been driven out from the pea-size dolomite within 18½ hours (1,540 deg. F.), while only 80 per cent. escaped in the same period and at the same temperature in the case of finely ground material. Based on these preliminary experiments

a burning temperature of 2,120 deg. F. was chosen, and burning extended over a period of two hours.

For each experiment 50 gr. of dolomite were used. After burning, 27 to 28 gr. of an oxide mixture resulted, which contained 15 to 17 gr. of calcium oxide and 9 to 11 gr. of magnesia. After shaking this mixture with 200 ccm. of boiling water the suspension remained for 12 to 18 hours. When the water was increased to a total of 1,000 ccm. the addition of bicarbonate of potassium took place. As 50 gr. of raw material contain about 10 gr. of magnesia, the calculation of the bicarbonate was as follows:



The suspension of 1,000 ccm. therefore contained 27 to 28 gr. of burnt dolomite and 22 to 25 gr. of bicarbonate of potassium. The reaction was accelerated by a stirrer revolving 400 to 500 times per minute, and carbon dioxide was continuously introduced into the flask.

The reaction was finished after about six hours, most of the lime being precipitated as carbonate within this period. Impurities present in the raw dolomite were also precipitated. The separation of the solution from the insoluble residue was carried out with the aid of a suction-filter. After washing the residue was dried and weighed. It amounted usually to 30 to 32 gr. The composition of the residues was very constant, as may be seen from the following.

COMPOSITION OF LIME RESIDUES.

No. of experiment.	CaO.	MgO.	CO ₂ .
7	47.88 per cent.	4.38 per cent.	44.54 per cent.
8	44.33 ..	7.57 ..	44.98 ..
9	50.34 ..	2.39 ..	44.40 ..
10	50.79 ..	2.54 ..	43.40 ..
11	49.50 ..	4.38 ..	43.16 ..
16	49.59 ..	4.40 ..	42.38 ..
17	49.49 ..	4.01 ..	42.20 ..
19	50.22 ..	3.77 ..	42.44 ..
Average ..	49.01 ..	4.08 ..	43.43 ..

It is not difficult to dissolve the total content of magnesia if the stirring and the introduction of carbon dioxide are continued longer than six hours. From an economical viewpoint, there is no need to do so, because the intensity of the reaction diminishes with the duration of the reaction. In any case, the composition of the residues shows that 87 to 90 per cent. of the total magnesia dissolves within six hours.

The reaction may be controlled titrimetrically by defining the alkalinity of the KHCO₃ solution and by measuring its increase due to the gradual dissolution of magnesia. It is more simple to control the degree of reaction by measuring the temperature of the solution at regular intervals. Starting with a strong

reaction it diminishes gradually until the temperature is the same as that of the room. The following table shows results of such measurements.

INCREASE OF TEMPERATURE IN DEG. F. DURING THE REACTION.

Time after.	No. of experiment.					Average value.
	11	12	13	14	15	
15 minutes	5.4	8.1	9.7	8.8	8.8	8.2
30 "	—	14.7	14.9	14.9	13.2	13.7
45 "	—	—	16.5	17.4	15.4	16.4
1 hour	14.4	9.9	15.9	16.2	14.0	14.1
2 hours	9.6	7.2	8.6	8.8	7.7	8.4
3 "	7.2	9.9	5.0	6.0	4.5	6.5
4 "	—	8.1	3.4	3.2	1.4	4.0
5 "	2.9	1.8	1.8	1.2	0.7	1.7
6 "	0.9	0.0	0.0	0.0	0.0	0.18

These temperature measurements indicate that the reaction is strongest during the first hour and then diminishes gradually until the temperature is the same as that of the room. The rate of the increase of temperature, and hence that of the reaction, depends upon (1) the number of revolutions of the stirrer per minute, (2) the amount of introduced carbon dioxide, and (3) the velocity and homogeneity with which the carbon dioxide is distributed in the solution.

The amount of lime in the residues was derived from the amount originally present in the raw material. The calculation of the amount of magnesia was derived in two ways; first, it was calculated with respect to the amount present in the raw dolomite, and secondly, with respect to the amount of magnesia which was dissolved after deduction of the small amount precipitated with the calcium carbonate.

The separation of the magnesia from the potassium-magnesium salt, which is also possible in vacuo, was effected by heating the solution to 212 deg. F. After boiling for 15 minutes the solution was filtered from the residue containing magnesium carbonate. The precipitate of $MgCO_3 \cdot 3H_2O$ was washed until the filtrate showed that potassium was no longer present. The air-dried $MgCO_3 \cdot 3H_2O$ was then burnt until constancy of weight and weighed as MgO . The following table shows the efficiency of the process.

No. of experiment.	Dolomite No.	Regain in lime.		Regain in Magnesia.		
		Gr.	Per cent.	Gr.	Per cent.*	Per cent.†
10	1	15.98	97.36	—	—	—
11	1	15.67	95.41	—	—	—
16	2	15.33	96.79	7.68	85.95	74.86
17	2	15.80	99.79	8.72	96.64	85.01
19	2	16.47	100.00	8.92	98.24	86.98

* Percentage with respect to the impurities in the residue of calcium carbonate.

† Percentage with respect to the content of the raw dolomite.

The separated magnesia proved to be nearly chemically pure, because no silica or sesquioxides could be detected by analysis. Only traces of calcium

oxide could be discovered occasionally. The content of magnesia nearly always amounted to more than 99 per cent., as may be seen from the values in the following table :—

No. of experiment.	Content of MgO.	No. of experiment.	Content of MgO.
	Per cent.		Per cent.
15 	99.62	20 	99.91
17 	100.00	22 	96.50
19 	99.93		(stirred for only 4 hours).

SUMMARY.

(1) By treating burnt dolomite with CO_2 and KHCO_3 a separation of the dolomite occurs in such a manner that calcium carbonate is precipitated, while $\text{MgCO}_3 \cdot \text{KHCO}_3 \cdot \text{H}_2\text{O}$ dissolves in solution.

(2) The final product is nearly pure magnesia after an intermediate precipitate of $\text{MgCO}_3 \cdot 3\text{H}_2\text{O}$.

(3) The lime residue may be used as a fertiliser.

(4) The solution of potassium bicarbonate can be re-used.

Estimation of Particle Size.

The following note is from the "Technical News Bulletin" of the National Bureau of Standards of the United States Department of Commerce :—

The importance of the effect of sub-sieve fineness on the properties of pulverised materials is becoming more generally recognised. For example, the covering power of mineral pigments and the rate of hardening of Portland cement are now known to be dependent upon grain sizes much smaller than the meshes of the finest sieves. This knowledge and the realisation of the necessity of closer control of the grinding processes, both for economy of operation and for uniformity of product, has resulted in an intensive investigation of methods of determining sub-sieve sizes. Mr. J. R. Gran, of the Cement and Concrete Section of the Bureau, has compared the principal methods in use for the determination of particle size gradation by microscopic measurement, sedimentation, and elutriation. His work shows the inherently arbitrary nature of all such measurements. In addition, it appears that much of the disagreement between results of different methods is caused by differences in the basic assumptions, such as the definition of the diameter of a single particle and the calculation of an average diameter of a group of particles.

Two sedimentation methods, the hydrometer and turbidimeter, have been compared by tests on a Portland cement, three pozzolanic materials, and three cements made by blending Portland cement and pozzolana. These tests show that while the results of one method do not agree with those of the other, because of differences in interpretation of the results, both methods may be equally suited to Portland-pozzolana cements.

Strength of Asbestos Cement.

IN our contemporary, *Zement* (No. 17, 1936), G. Rosenbaum states that the increasing use of asbestos cement for moulded and hollow bodies in which various strength conditions are required call for further knowledge of the factors on which the strength depends. The following influences affect the strength of asbestos cement: (1) the quality of the asbestos and of the cement; (2) the nature and quality of any aggregate or diluent; (3) the conditions of manufacture; and (4) the setting and hardening properties of the product. The following is an abstract of the article mentioned.

With reference to the asbestos and the strength of the product it is necessary to consider: (a) the type of asbestos; (b) the length of its fibres; and (c) the proportion of asbestos to cement. Of the known types of asbestos, amphibole asbestos is not considered as it is hardly suitable for the asbestos-cement industry. Chrysotile-serpentine asbestos is at present used almost exclusively in this industry. Amosite and blue asbestos are used only when it is difficult to obtain medium-length chrysotile fibres. In these cases the mix "felts" better and the output is favourably influenced, but the fibres, in spite of their considerable length, are not so strong as chrysotile fibres of equal length (see *Table 1*).

TABLE 1.

Type of asbestos	Source	Ratio of asbestos to cement	Sieve test on asbestos, per cent.	Breaking strength of asbestos cement (kg. per cm. ²)	Remarks
Amosite	Lapland	1 to 8.75	90—4—3—3	201	Unpressed material
Blue asbestos	Lapland	1 to 8.75	88—6—4—2	187	
Chrysotile	Urals	1 to 8.75	81—12—4—3	242	
Chrysotile	Rhodesia	1 to 8.75	83—10—4—3	253	

The sieve tests were made on beaten asbestos so that the fibres were in the same state of preparation for each test, and difficulties due to the fibres being delivered in the various states of openness, known as hard and soft fibres, were avoided. The tests were made on a Canadian shaking machine, but the sieve residue was obtained by another apparatus of which the mesh width corresponded better to the usual fibre lengths.

The breaking strength was determined in a Michaelis machine at an age of 28 days and in a direction at 45 deg. to the length of the fibres. Each test was duplicated and the strengths obtained are the mean of four determinations from each test.

The four types of asbestos in *Table 1* differ in chemical composition but only very slightly in fibre length, whereas those in *Table 2* are all of the same type, namely, chrysotile. These differ in the lengths of their fibres.

The table shows the increase in breaking strength with increase in the fibre length. The breaking strength of the plates made with Canadian asbestos is

less than that of those made with the shorter-fibre Urals asbestos, but this is explained by the high talc content of the Canadian asbestos.

TABLE 2.
DEPENDENCE OF STRENGTH ON FIBRE LENGTH.

Type of asbestos	Source	Sieve test (per cent.)	Dust content (per cent.)	Ratio of asbestos to cement	Breaking strength of asbestos cement (kg. per cm. ²)	Remarks
Chrysotile	Urals	96—2—2—0	0.8	1 to 12.5	446	Tests made with after-pressed material
	"	80—12—4—4	1.5	1 to 12.5	377	
	"	4—31—44—21	9.0	1 to 8.3	344	
	Rhodesia	82—6—6—6	2.5	1 to 12.5	383	
	"	3—59—31—7	4.0	1 to 8.3	360	
	Cyprus	26—43—23—8	0.5	1 to 12.5	325	
"	Canada	17—38—31—14	10.5	1 to 8.3	288	

Table 3, deduced from Table 2, gives the results of tests with equal proportions of asbestos and cement, and shows the dependence of the strength on the content of long fibres.

TABLE 3.

Source	Proportion of long fibres (per cent.)	Breaking strength (kg. per cm. ²)
Urals	96	446
Rhodesia	82	383
Urals	80	377
Cyprus	26	325

The dust content of the asbestos added to the cement was determined by sieving on a 900-mesh (72×72) sieve. This dust is only a diluent of the cement and reduces the strength. Table 4 shows the dependence of strength on the content of the non-fibrous portion of the asbestos.

TABLE 4.

Source	Dust content (per cent.)	Breaking strength (kg. per cm. ²)	Percentage of long fibres	Sum of percentages of longest and second longest fibres
Rhodesia (short fibre) ..	4.0	360	3	62
Urals ..	9.0	344	4	35
Canadian ..	10.5	288	17	55

It will be noted that the strength drops with an increase in the dust content, but in this case does not increase with the content of long fibres or with the sum of the percentages of the longest and second longest fibres in the Ural and Canadian types in Table 4. Thus an asbestos-cement made with a shorter-fibre

asbestos, low in dust, can give a higher breaking strength than one made with a longer-fibre asbestos with a higher dust content.

Increasing the proportion of asbestos to cement is often supposed to cause a fall in the strength of the product. Actually, cases where the asbestos : cement ratio falls below 1 : 3 only apply to asbestos-board and are outside the range of mixes used in the asbestos-cement industry. In the products of the latter, the strength rises with increasing content of asbestos, especially of the long-fibre variety. When the asbestos contains talc, the increase in strength with increase in the proportion of asbestos is not very appreciable owing to the increasingly detrimental action of the talc.

Table 5 shows the effect on strength of an increase in the proportion of asbestos of the chrysotile type with different lengths of fibre.

TABLE 5.
INFLUENCE OF FIBRE LENGTH AND ASBESTOS : CEMENT RATIO ON STRENGTH.

Group No.	Source	Fibre degree	Test	Ratio of asbestos to cement	Breaking strength (kg. per cm. ²)	Remarks
1	Urals	II	100—0—0—0	1 : 25.0	340	a
	Urals	II	100—0—0—0	1 : 16.6	380	
2	Urals	III	96—2—2—0	1 : 16.6	350	b
	Urals	III	96—2—2—0	1 : 12.5	44 ^b	
3	Urals	IV	80—12—4—4	1 : 12.5	377	a
	Urals	IV	80—12—4—4	1 : 8.75	444	
4	Canada	4 Z	17—38—31—14	1 : 8.75	288	Asbestos contains talc
	Canada	4 Z	17—38—31—14	1 : 6.25	312	
5	Rhodesia	4 S	3—59—31—7	1 : 8.75	350	b
	Rhodesia	4 S	3—59—31—7	1 : 7.15	408	
	Rhodesia	4 S	3—59—31—7	1 : 6.25	417	

If mixtures of asbestos are used the composition of the fibres by length in the mixture is additive.

Table 6 shows that the strength of the hydraulic binding material is not as important as the strength of the asbestos.

TABLE 6.
INFLUENCE OF CEMENT STRENGTH ON THE STRENGTH OF THE ASBESTOS CEMENT.

Cement sample	Tensile strength (kg. per cm. ²) of 28 days 1 : 3 mortar	Ratio of strengths	Breaking strength of asbestos cement (kg. per cm. ²)	Ratio of breaking strengths
A	38.9	1.0	337	1.0
B	41.3	1.06	340	1.01
C	46.2	1.18	346	1.03

Influence of Foreign Additions on the Strength of Asbestos Cement.

In general, the strength is reduced by (1) colouring materials; (2) fillers; (3) ground asbestos-cement waste products; and (4) asbestos-cement slurry from the cleaning vats.

The strength of cement has been tested in relation to the strength of the cement when adulterated with talc and other substances.

Table 7 shows the effect of various materials used as diluents on the tensile strength of cement.

TABLE 7.
CEMENT STRENGTH AS INFLUENCED BY VARIOUS ADDITIONS.

Mixture	Tensile strength at 28 days in (kg. per cm. ²)
Pure cement	55
3 parts cement + 1 part limestone	45
3 parts cement + 1 part graphite	42
3 parts cement + 1 part natural slate dust	39
3 parts cement + 1 part talc	34

The diluents were used as delivered and are said to be in forms specially suitable for asbestos-cement production. The talc is from a Canadian asbestos quarry, and produces a comparatively large reduction in strength.

Colouring materials act as diluents of the cement, and their effects are well known. Certain natural red colours have very little effect on the strength of cement.

Ground asbestos-cement waste products reduce the strength; a 10 per cent. addition of finely ground waste reduces the strength by 15 per cent. Manufacturers who cut products from sheets know that the addition of still unhydrated waste products to the materials in the beating machine reduces the strength of the ware. It is also common knowledge that the recovered slurry which goes through the filter has a bad influence on the setting-time and strength of the asbestos cement; in one case, the setting time was doubled and the strength reduced by 20 per cent.

Influence of Working Conditions on Strength.

The influence of the working conditions is, in general, much greater than is generally believed, especially the speed of working and the thickness of the material in the machines. *Table 8* shows how the strength depends on the thickness of the fibre layer (felt on the drum) which, in turn, depends on the thickness of the material in the machine. This series of tests was made on a two-cylinder board-making machine, with a suction surface 30 cm. wide and a working vacuum of 40 cm. The felt speed was equal in all cases, namely, 22 metres per minute.

TABLE 8.
DEPENDENCE OF STRENGTH ON THICKNESS OF FELT LAYER.

Thickness of felt layer (mm.)	Breaking strength (kg. per cm. ²)		Remarks
	Pressed ware	Unpressed ware	
1.25	283	137	28-day strengths on plates tested dia- gonally
1.00	302	139	
0.72	313	163	
0.50	323	168	

The dependence of the strength of the material on the pressure which is put on the ware after manufacture or while in the board-making machine raises the question whether in countries free from snow or frost, it is necessary to press the ware after it passes through the machine.

TABLE 9.
DEPENDENCE OF THE BREAKING STRENGTH ON THE PRESSURE USED IN THE
AFTER-PRESSING PROCESS.

Pressure used in after-pressing process (kg. per cm. ²)	Thickness of plate (mm.)	Total breaking load (kg.)	Breaking strength (kg. per cm. ²)
0	5.4	148	213
50	5.0	146	247
100	5.2	162	250
150	4.8	157	282
200	4.6	150	305
300	4.3	150	330
400	4.2	146	346

The figures in *Table 9* show that the breaking load of a plate prepared with a certain thickness remains the same when one presses this plate, that is, the breaking load depends on the amount of material in the plate.

A property which also depends on the method of working is the difference of the strengths in directions parallel and normal to the fibres in the plate, so that in hollow bodies the strength of the material occurs tangentially (or radially). When plates were manufactured in hydraulic machines this difference of strength in different directions did not usually arise because there was no particular orientation of the fibre directions. In the case of the board-making machine, however, the fibres are orientated in the direction of the run of the felt and give 30 to 60 per cent. greater strength in this direction than in the normal direction. This difference of strength is the greater, the longer the fibres in the mixture. In corrugated sheets and tubes, this difference of strength often causes unsatisfactory results. The Dalmine process and the Hloch patent tend to offset these troubles by crossing the fibres.

With regard to the relation of the strength to setting and hardening, any factor that increases the strength of the cement also raises the strength of the asbestos cement even when the influences of these factors are not so strong as

in the case of cement products without asbestos. Just as the strength of cement products is raised by water curing, so the strength of asbestos-cement ware can be raised by 15 per cent. by curing in a similar manner.

In the earlier days most asbestos-cement works used to speed up the setting time by storing in a warm room to economise in moulds ; no account was taken of the risk of spoiling the strength thereby. To-day greater importance is laid on the hardening process of cement, because either proper water storage (as for tubes) or air seasoning is used in order to obtain the most favourable hardening conditions.

A curing room into which steam is injected has often been used to speed up the setting and facilitate the early removal of moulds. Curing in this way is much debated, for some cements stand this treatment whilst others do not. A mixture rich in asbestos generally avoids these difficulties ; a slow rise of temperature, not exceeding 45 deg. C., followed by water storage seldom results in the ware being spoiled. In order to harden roofing tiles quickly one important works uses carbon dioxide gas and obtains a rapid rise of strength ; the colour is safe and efflorescence is avoided because the free CaO is carbonated in the curing. After three days of this treatment the strength is equivalent to that obtained at twenty-eight days with an untreated specimen. In most works it is want of space which prevents the goods being handled in the way most favourable for hardening.

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Recent Patents Relating to Cement and Lime.

Porous Concrete.

469,220.—G. Hannecart. Oct. 23, 1936.

A small percentage of powdered glue or other albuminoid substance is mixed with cement, either in the cement grinder or in a homogenising machine. To produce a cellular concrete, water is added to the cement as treated and the mixture agitated by hand or mechanically until froth is produced.

Refractory Substances.

468,456.—Magnesit-Industrie Akt.-Ges. Jan. 9, 1936.

Magnesite bricks are made from a mixture of sintered magnesite and from 10 to 30 per cent., referred to the weight of the brick, of chromium ore, and a substance, e.g. corundum, rich in alumina, the amount of the substance rich in alumina being about 4 to 7 per cent. of the weight of the brick. The alumina is preferably in the form of fine meal, and the magnesite and chrome ore partly fine meal and partly coarse grains of 1 to 5 mm. In an example, a composition comprises 15 parts of magnesite fine meal, 55 parts of magnesite coarse grains 1 to 2.5 mm., 10 parts chrome ore fine meal, 15 parts chrome ore coarse grains, and 5 parts corundum.

Cements.

466,229.—Dewey & Almy, Ltd. (Dewey & Almy-Chemical Co.). Feb. 12, 1936.

Cement clinker is ground in the presence of an aqueous solution or dispersion of an agent which is effective to peptise cement particles in an aqueous medium without diminution of the strength of the hardened concrete subsequently produced, of a wetting agent, or of an oleaginous material.

One group of peptising agents which may be employed is soluble organic compounds containing a number of aromatic nuclei directly attached to an aliphatic nucleus, for example the compound obtained by condensing beta-naphthalene sulphonic acid with formal-

dehyde as described in Specification 431,679. Other peptising agents are water soluble derivatives of lignin, e.g. the water soluble salt of lignin sulphonic acid. These are preferably used in the presence of hydroxyalkyl amines disclosed in Specification 454,944.

A further group of peptising agents comprises water soluble organic compounds of at least 15 carbon atoms and containing in the molecule two or more aromatic nuclei attached to a heterogeneous nucleus, e.g. fast wool cyanone 3R, Durol black 2B, Durol black B, wool violet 4BN, Nigrosene 12525. Other compounds are the isothionic esters of oleic acid.

Suitable wetting agents are sulphonates of higher alcohols, soaps, saponins, sulphonation products of alkylated poly-nuclear aromatic hydrocarbons, e.g. butyl naphthalene sulphonic acid and sulphuric acid esters of high fatty alcohols. As oleaginous material, oleic acid may be employed. The amount of peptising agent used is about 1½ parts to 1,000 parts of cement. When wetting agents are used the amount is about 2 parts to 1,000 of cement, and in the case of oleaginous materials from 0.5 to 10 parts per 1,000. The amount of water is preferably not more than 1 part to 50 of cement and not less than 1 part to 1,000 of cement.

Concretes and Cements.

466,639.—Dewey & Almy, Ltd. July 23, 1936.

A water-soluble derivative of lignin is added to a hydraulic cement-aggregate-water concrete mix, or to powdered hydraulic cement or in solution in water to the clinker as it enters the Hercules or Compeb mills, or to the partially ground clinker, in an amount effective to peptise and disperse the cement particles uniformly throughout the concrete mix. Generally, not more than 2 parts of lignin derivative are added to 1,000 parts of cement. The derivative may be tricalcium lignin sulphonate; lignin salts formed by replacing all or part of the combined calcium in the said sulphonate by hydrogen, alkali metals or ammonia, or by treating the said sulphonate with

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Patents.—(Continued.)

hydrochloric, sulphuric or carbonic acid; salts of lignin disulphonate (the latter may be made by treating the above-mentioned sulphonate with sulphur dioxide); sodium lignate separated from black liquor and purified; the sodium salt of the condensation product of lignin and ethylene glycol; chloro lignin; or phenol derivatives of lignin. Specifications 244,603 [Class 22] and 431,679 are referred to.

Cements.

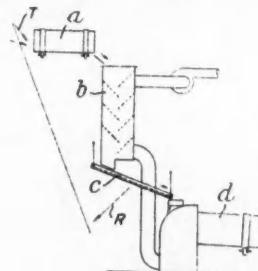
470,365.—Dewey & Almy, Ltd. Feb. 12, 1936.

Cement clinker is ground in the presence of a water soluble hydroxyl amine, or a salt or derivative thereof, e.g. triethanolamine diethanolamine or tri-isopropanol amine or a salt thereof. The amount added may be one part of 2,000-14,000 of cement. The addition may be made in the form of an aqueous solution.

Cement.

470,267.—N. Ahlmann. Feb. 11, 1936.

Cement slurry prior to calcination is formed into nodules and dried, and a part of the nodulated material, before it is calcined to any substantial extent, is withdrawn and mixed with raw slurry to form a mixture which is converted



into fresh nodules. As shown, raw slurry is nodulated in a drum (a) and the nodules pass to a dryer (b) in the form of a louved shaft heated by waste gases from the rotary kiln (d). The dried nodules fall on to a jiggling screen (c), and the smaller nodules are separated and returned to the drum (a) as indicated by the arrows (R, T).

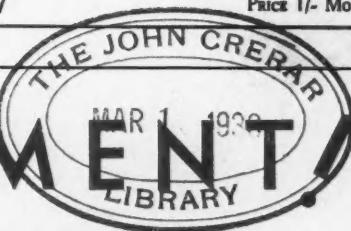
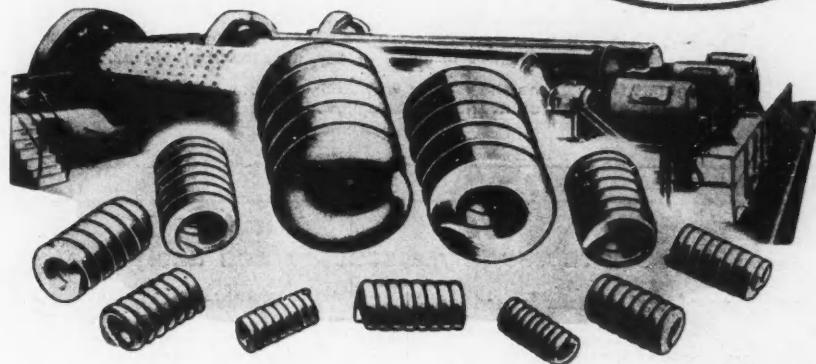
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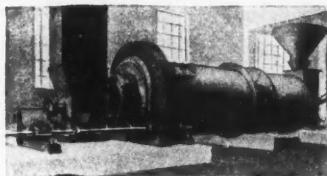
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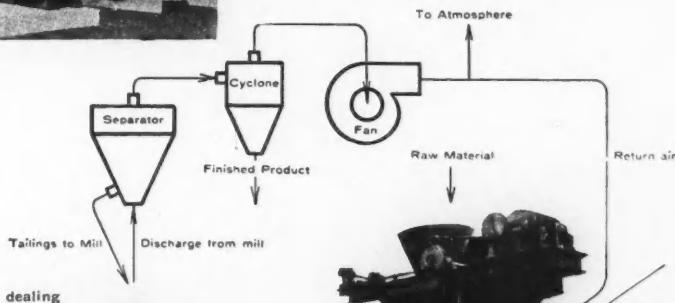
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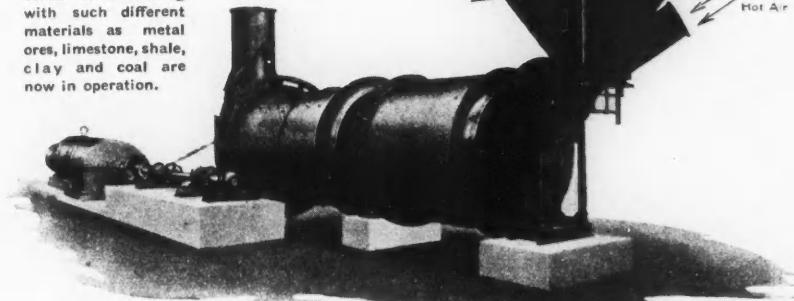
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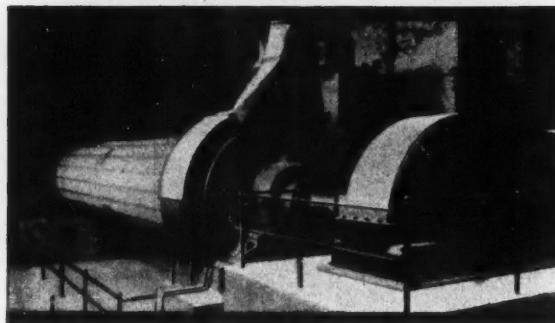
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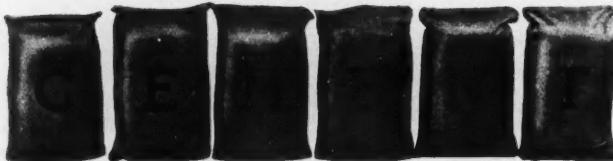
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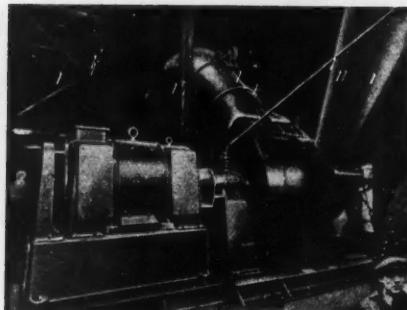
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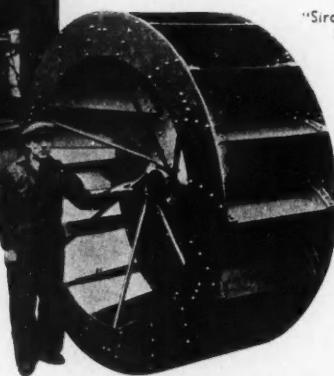
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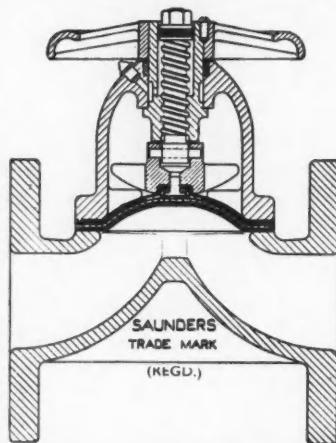
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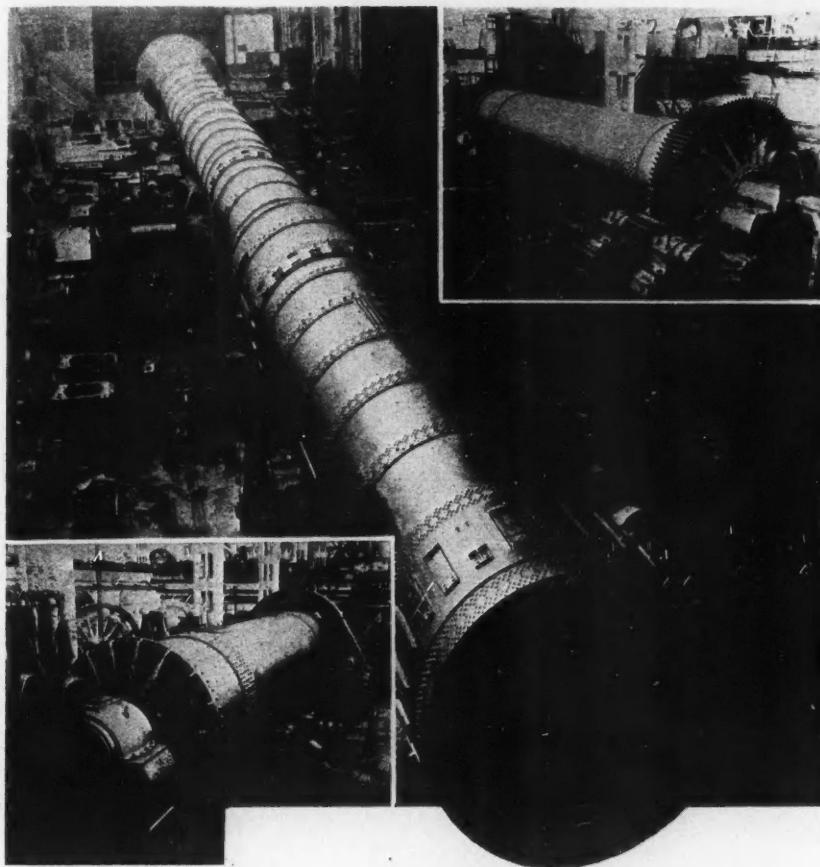
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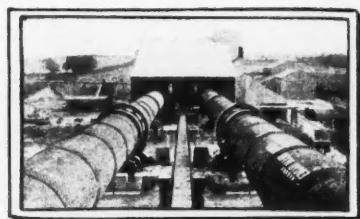
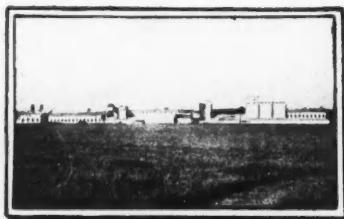
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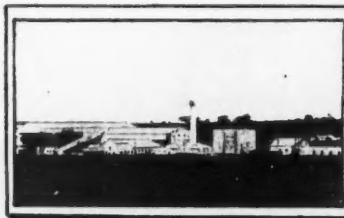


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